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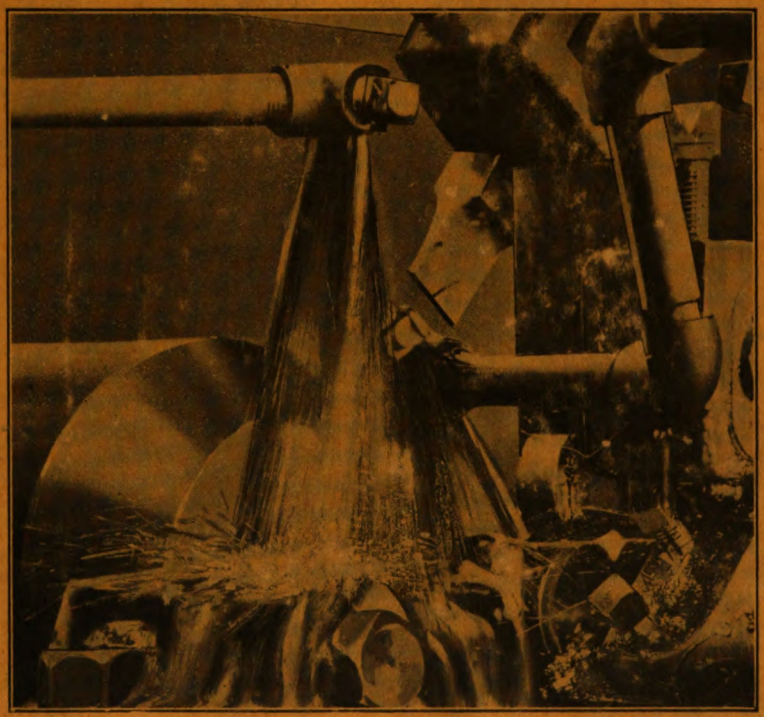
CUTTING LUBRICANTS

COOLING AND LUBRICATING COMPOUNDS FOR MACHINING OPERATIONS—PUMPS, PIPING SYSTEMS, OIL PANS AND TANKS



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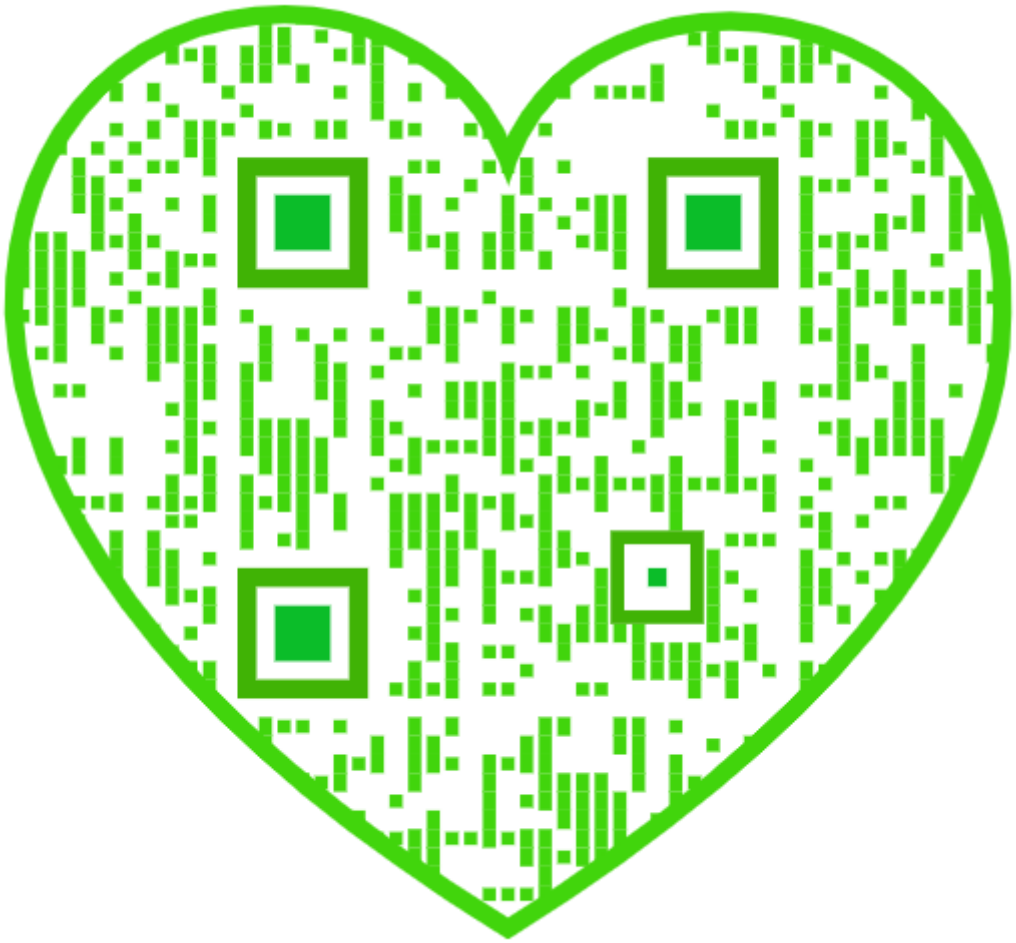

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NUMBER 124

CUTTING LUBRICANTS

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CHAPTER I

CUTTING LUBRICANTS FOR MACHINING OPERATIONS

Cutting lubricants are used in connection with most machining operations on wrought iron and steel, in order to cool the turning tool and reduce the abrasion or wear of the cutting edge, thus permitting higher cutting speeds. In many cases, however, lubricants are not used even when machining iron and steel. This may be due to the nature of the work or to the inconvenience of supplying a lubricant when the machine is not equipped for it. For instance, small turning operations in the lathe are usually performed dry or without a lubricant, regardless of the material being turned, especially when the cuts are light and the application of oil or a soda-water mixture to the tool would interfere with the work. When there is considerable superfluous metal to be removed and long roughing cuts must be taken, a good lubricant, while not necessary, is very desirable, as it permits higher cutting speeds and preserves the edge of the tool.

Many modern lathes, particularly the large sizes or those of the "manufacturing type," are equipped with pumps and piping to automatically supply a continuous stream of lubricant for the turning tool. Most lathes, however, are not so equipped and lubricant is generally supplied from a cam which is mounted at the rear of the carriage and travels with the tool as it feeds along the work. The objection to the use of a cam from which the lubricant flows by gravity is that the amount of lubricant is insufficient to properly cool the tool when taking heavy roughing cuts. The result is that the full benefit from the use of the lubricant is not obtained. (The different methods of supplying lubricant to turning tools and cutters on various machines is explained in Chapter II.) Cutting lubricants are more generally used on turning and milling machines of various types than on planing and slotting machines. In fact, cutting lubricants are not often used for rough planing operations, although in many cases a lubricant would be desirable. The same is true of many other operations which are ordinarily performed dry. Frequently a lubricant, such as soda-water, is used on the planer or shaper when taking light finishing cuts. The object, however, is to secure a smooth surface rather than to increase the durability of the tool or permit higher cutting speeds.

Quite a variety of cutting lubricants are used at the present time, some being compounds which are "home-made" and others commercial lubricants which have been placed on the market. Most of the following lubricants for different materials and operations are in general use and have proved satisfactory.

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Lubricants for Turning Operations: A good grade of lard oil is an excellent lubricant for use when turning steel or wrought iron and is extensively used on automatic screw machines, especially those which operate on comparatively small work. For some classes of work, especially when high-cutting speeds are used, lard oil is not as satisfactory as soda-water or some of the commercial lubricants, because the oil is more sluggish and does not penetrate to the cutting point with sufficient rapidity. Many lubricants which are cheaper than oil are extensively used on "automatics" for general machining operations. These usually consist of a mixture of sal-soda (carbonate of soda) and water, to which is added some ingredient such as lard oil or soft soap, to thicken or give body to the lubricant.

A cheap lubricant for turning which has been extensively used is made in the following proportions: 1 pound of sal-soda (carbonate of soda), 1 quart of lard oil, 1 quart of soft soap, and enough water to make 10 or 12 gallons. This mixture is boiled for one-half hour, preferably by passing a steam coil through it. If the solution should have an objectionable odor, this can be eliminated by adding about 2 pounds of unslaked lime. The soap and soda in this solution improve the lubricating quality and also prevent the surfaces from rusting.

A mixture of equal parts of lard oil and paraffin oil will also be found very satisfactory for turning operations, the paraffin being added to lessen the expense. Another mixture is made by adding 10 gallons of lard or paraffin oil to a No. 10 can of "Oildag." For automatic screw machine work, a good lubricant is composed of equal parts of so-called "electric cutting oil" and paraffin oil.

Lubricants for Milling: For milling operations the following compound (which is also adapted to turning) is often used. Mix together 1 pound of sal-soda, 1 quart of lard oil, 1 quart of soft soap and enough water to make 10 or 12 gallons. Boil this mixture one-half hour. For general work in milling steel, the following formula has been successfully employed: Mix 96 pounds of "Cataract" compound and 21 gallons of pure water; take 12 gallons of this stock mixture, add 48 gallons of water and two No. 10 jars of "Aquadag"; mix thoroughly.

A mixture of equal parts of lard oil and paraffin oil is also used for milling, the paraffin being added to reduce the cost of the lubricant. For fluting operations, paraffin oil, not mixed, has proved satisfactory.

Compounds for Drilling: A cheap drilling composition can be made by adding to thirty gallons of water 5 gallons of lard oil and 20 pounds of washing soda. Put the material in a lard oil barrel, insert a steam hose into the bung and boil thoroughly. Do not use mineral oil or a barrel that has contained it. Another cheap drilling compound is made in the following proportions: Mix 96 pounds of "Cataract" compound and 21 gallons of pure water; to 12 gallons of this stock mixture add 48 gallons of water and two No. 10 jars of "Aquadag"; mix thoroughly.

When drilling hard and refractory steel, use turpentine, kerosene or soda water; for soft steel and wrought iron, lard oil or soda water; for malleable iron, soda water; for brass, a flood of paraffin oil, if any lubricant is used; for aluminum and soft alloys, kerosene or soda water. When drilling glass use a mixture of turpentine and camphor. Cast iron should be worked dry, or with a jet of compressed air as a cooling medium. When drilling very deep holes in cast iron, a few drops of kerosene deposited on the drill point will be found useful, but care must be taken to use a very small amount of the lubricant. For deep-hole drilling in steel use a mixture of equal parts of lard oil and paraffin oil. When drilling rawhide, apply ordinary laundry soap to the drill at frequent intervals. The drilling of hard material is facilitated by using turpentine as a cutting compound and by grinding off the sharp angles of the cutting edges so as to permit quite heavy feeds without chipping the edges. This form of point will also be found advantageous for drilling soft material, like brass, as it does not tend to dig into the metal. It is good practice to warm the lubricant before using it on high-speed steel tools. These work much better when warm, often giving good results when the chips are turned blue by the heat generated. Nothing will check a high-speed drill quicker than turning a stream of cold water onto it after it has become heated. It is equally bad to plunge the drill into cold water after the point has been heated in grinding.

Lubricant for Grinding: For grinding with hard or soft wheels, use a No. 10 jar of "Aquadag" mixed with ten gallons of water; add one-half pound of borax or sal-soda to prevent rusting.

Lubricant for Gear Cutting: The following mixture has been extensively used on gear-cutting machines: 3½ gallons of mineral lard oil, 2¾ pounds of sal-soda, and one barrel of soft water.

Effect of Lubricant when Turning Cast Iron: Cast iron, except when tapping, is usually machined dry. Experiments made to determine the effect of applying a heavy stream of cooling water to a tool turning cast iron showed the following results: Cutting speed without water, 47 feet per minute; cutting speed with a heavy stream of water, nearly 54 feet per minute. Increase in speed 15 per cent. The dirt caused by mixing the fine cast-iron turnings with a cutting lubricant is an objectionable feature which, in the opinion of many, more than offsets the increase in cutting speed that might be obtained.

Lubricants for Thread Cutting: A mixture of equal parts of lard oil and paraffin oil gives good results for threading. (The lard oil is adulterated with paraffin to reduce the cost of the lubricant.) For thread cutting on nickel steel or other hard stock, with machines running at high speed, the following compound has proved satisfactory: To 8 gallons of warm water add 25 to 30 ounces of borax. When fully dissolved, add two gallons of lard oil and stir thoroughly. When cold, add the contents of a No. 10 jar of "Aquadag" (condensed); mix thoroughly. An excess of borax will be indicated by the formation

of more than two or three bubbles on the surface of the mixture after thorough stirring. Ordinary beeswax is a good lubricant to use when cutting threads in copper. The beeswax is rubbed onto the thread and produces a smooth finish.

Lubricants for Brass, Babbitt and Copper: Brass or bronze is usually machined dry, although lard oil is sometimes used for automatic screw machine work. Babbitt metal is also worked dry, ordinarily, although kerosene or turpentine is sometimes used when boring or reaming. If babbitt is bored dry, balls of metal tend to form on the tool and score the work. Milk is generally considered the best lubricant for machining copper. A mixture of lard oil and turpentine is also used for copper.

Lubricants for Machining Aluminum: For aluminum, the following lubricants can be used: Kerosene, a mixture of kerosene and gasoline; soap-water; or "aqualine" one part, water twenty parts. The last mixture specified has been successfully used by the Brown-Lipe Gear Co., where a great many aluminum parts are machined. This lubricant not only gives a smooth finish, but preserves a keen cutting edge and enables tools to be used much longer without grinding. Formerly a lubricant composed of one part of high-grade lard oil and one part of kerosene was used. This mixture costs approximately 30 cents per gallon, whereas the aqualine-and-water mixture now being used costs less than 4 cents per gallon, and has proved more effective than the lubricant formerly employed.

Lubricants for Broaching Operations: For broaching steel, cutting compounds similar to those used for other machining operations, such as turning and milling, are commonly used. The J. N. Lapointe Co. recommends a lubricant for broaching steel containing 2½ pounds of soda ash and 3 gallons of mineral lard oil to 50 gallons of water. The soda ash and lard oil is mixed with 10 gallons of water, and then the remaining 40 gallons of water added. When holes to be broached are of exceptional length, a good grade of oil is better than soda water or similar cutting lubricants, as the oil will cling to the cutting edges of the broach for a longer time.

Lubricants for Tapping: The breakage of taps can be reduced greatly by using the proper lubricant. A good grade of animal lard oil, sperm oil, and graphite and tallow mixtures (10 per cent graphite, 90 per cent tallow) are the best lubricants to use when tapping steel or iron. A good soap compound is better than "mineral lard oil." Machine oil is a poor tapping lubricant. Tests made to determine the power required for tapping demonstrated that the power required when using sperm oil is 16.5, as compared with 34.2 when machine oil is used. Incidentally, this increase is almost as great as that due to decreasing the diameter of the tap drill from 0.425 to 0.400 inch when using sperm oil, the increase being from 16.5 to 35.5. This shows that a poor lubricant may increase the power for tapping as much as would a considerable reduction in the diameter of the hole to be tapped.

For tapping cast iron, soap compounds give excellent results, and lard oil is also used. Oil for cast iron, however, has the disadvantage of causing the chips to stick in the tap flutes, thus preventing the lubricant from reaching the cutting edges; hence a thin lubricant is preferable. A few drops of kerosene will facilitate the tapping of long holes in cast iron. Only a small amount of kerosene should be used.

Lard Oil as a Cutting Lubricant

After being used for a considerable time, lard oil seems to lose some of its good qualities as a cooling compound. There are several reasons for this. Some manufacturers use the same oil over and over again on different materials, such as brass, steel, etc. This is objectionable, for when lard oil has been used on brass it is practically impossible to get the fine dust separated from it in a centrifugal separator. When this impure oil is used on steel, especially where high-speed steels are employed, it does not give satisfactory results, owing to the fact that when the cutting tool becomes dull, the small brass particles "freeze" to the cutting tool and thus produce rough work. The best results are obtained from lard oil by keeping it thin, and by using it on the same materials—that is, not transferring the oil from a machine in which brass is being cut, to one where it would be employed on steel. If the oil is always used on the same class of material, it will not lose any of its good qualities.

Prime lard oil is nearly colorless, having a pale yellow or greenish tinge. The solidifying point and other characteristics of the oil depend upon the temperature at which it was expressed, winter-pressed lard oil containing less solid constitutents of the lard than that expressed in warm weather. The specific gravity should not exceed 0.916; it is sometimes increased by adulterants, such as cotton-seed and maize oils.

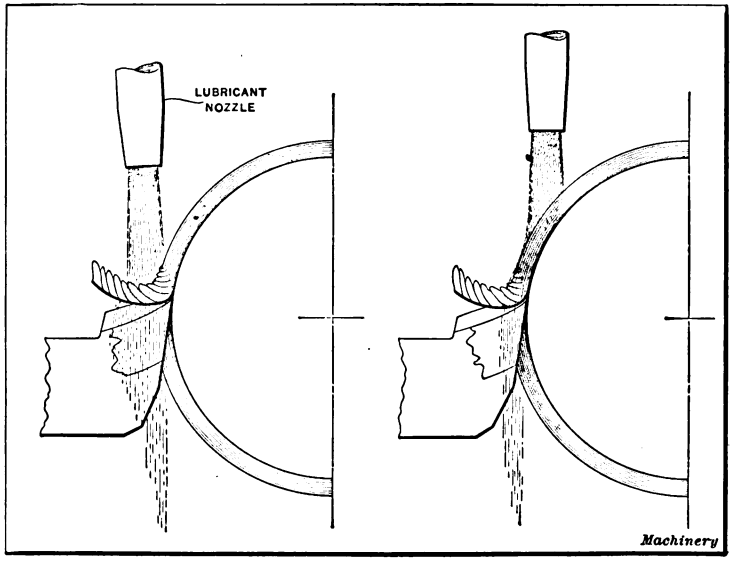
Navy Department Specifications for Lard Oil

The U. S. Navy Department gives the following specifications for lard oil: Lard oil must be of a good commercial quality, and must be purchased and inspected by weight; the number of pounds per gallon is to be determined by the specific gravity of the oil at 60 degrees F. multiplied by 8.33 pounds (the weight of a gallon of distilled water at the same temperature). Oil will not be accepted which contains a mixture of any mineral oil (10 per cent vegetable or fish oil is allowed); nor must the oil contain more acidity than the equivalent of 5 per cent of oleic acid, or show a cold test above 55 degrees F. The specific gravity must not be above 0.92 nor below 0.90.

Effect of Cooling Lubricant on Cutting Speed

Experiments made by Mr. F. W. Taylor, to determine the effect upon the cutting speed of pouring a heavy stream of cooling water upon the cutting edge of the tool, resulted in the following conclusions:

When using high-speed steel tools, a gain in the cutting speed of from 35 to 40 per cent can be made, when turning steel or wrought iron, by applying a heavy stream of cooling water at the proper point. In general practice, this percentage might be reduced somewhat, owing to the fact that the water is not always directed upon the right spot. The most satisfactory results are obtained from a stream of water falling at rather slow velocity but in large volume, because a stream of this sort covers a larger area and is much freer from splash.



Cooling Lubricant should be applied at Point where Chip is being severed, as shown by Diagram to Left, rather than as Indicated by View to Right

The stream of lubricant should fall directly upon the chip at the point where it is being removed by the tool. The left-hand view of the accompanying illustration shows how the stream should fall upon the tool and chip. Very often the water is thrown upon the work at a point above the chip to prevent splashing, as illustrated by the right-hand view. This method, however, of applying lubricant is less effective and results in a slower cutting speed.

The gain in cutting speed through the use of cooling water is practically the same for all qualities of steel from the softest to the hardest.

When cutting steel, the better the quality of the tool steel, the greater the percentage of gain through the use of cooling water. The gain for different types of tools when cutting steel was found to be as follows: Modern high-speed tools, 40 per cent; old-style self-hardening tools, 33 per cent; carbon steel tempered tools, 25 per cent.

CHAPTER II

LUBRICATING SYSTEMS FOR CUTTING TOOLS

The lubrication of cutting tools, like many other details of machine tool practice, has made great advances during recent years. Systems and methods that were at one period considered special and adapted only to a certain class of machine, are now applied commonly to various other types. New developments have also had their effect in increasing the demand for better methods of lubrication. There is considerable variation in the methods of lubricating tools, not only on different classes of machines, but on machines of the same type, the reason being two-fold: Either the work does not require the application of a lubricant, or the amount and manner of supplying the lubricant varies, ranging from a slight drip to a profuse flooding under pressure; this depends upon the nature and extent of the cut. For example, a light milling operation with a single cutter may need no more than a small supply from a drip-can, whereas, on the same machine, the operation of a gang of cutters for deep roughing cuts will require a large stream to flood the work thoroughly and wash the chips away. Some machine tools, such as brass-finishers' machines of many types, cylinder-boring machines, some lathes for machining castings only, and some of the reciprocating types of machines for brass or cast iron only, have no arrangements for lubrication of the tools. In many, a compromise is made so that the addition of a lubricating system is easily effected. In order to avoid a multiplicity of designs, some firms build certain of their machines with the channels, trays, etc., essential to the flooded system, and omit or supply the pump and piping as wanted.

The Amount of Lubricant

There are three principal reasons for the adoption of a lubricating system: One is to cool the tool or cutter, another to impart a smooth surface to the work, the third to wash away the chips. The first-named is frequently the only reason for the application of a lubricant. For instance, in many operations on brass and other alloys the surfaces would be tooled just as smoothly without the lubricant, but the tools would heat up, and the work would also become too warm if the operation were long-continued; hence the accuracy would be impaired, while the cutting edges would not endure for a sufficient length of time. On the other hand, drilling, particularly in deep holes, sometimes cannot be done at all unless the lubricant is fed with sufficient force to eject the chips as fast as they form. A quantity much in excess of the requirements for cooling alone is therefore required. When a metal or alloy cannot be tooled with a smooth

finish unless lubricant is employed, it may not be necessary to use a large quantity, so long as the edges of the tool and the portion of the work adjacent thereto are covered. The necessity for an increased supply soon arises, however, as speeds and feeds are increased; otherwise the film of lubricant will be too attenuated to spread as fast as the metal is cut into, and the result will be that intervals of dry cutting will occur, and the heat will evaporate the film to such an extent that it becomes useless. A further development is reached when the heat, caused by cutting, raises the temperature of the cooling medium to such an extent that the latter ceases to act effectually. This happens when the total amount of liquid is not large enough to provide for cooling in the intervals between successive applications to the cutting tool. The remedy is a much larger amount of liquid, and preferably a return tray of ample surface area, so that the maximum amount of area shall be exposed to the air. In extreme instances, two tanks may be utilized, each holding a large body of lubricant, which are drawn from alternately, thus affording intervals for each to cool somewhat.

The essentials involved in any system of lubrication are the supply, collection and separation from cuttings, and method of return. The first two requirements include many devices and modifications, ranging from the time-honored drip-can to elaborate pump and piping arrangements, and from a simple can hung beneath a table to a complete series of rims, chutes, troughs, pipes and strainers. The distinction between the two extremes is due to the quantity of lubricant required, since a simple system that is capable of feeding and collecting a few pints of liquid used at a slow rate is totally inadequate for the flooding method; neither is it automatic in action but necessitates frequent attention.

The amount and nature of the chips also materially affects the mode of collection and one method is not suitable for all cases. Large curling chips, and fine swarf (such as from a hacksaw) are very different as regards the separation of the lubricant from them, the swarf being much more difficult to separate. The bulk of the chips is also important in considering the method of collection and separation. If they occur in small quantities, very little extra accommodation beyond that necessitated by the liquid is wanted, but if there is a large bulk of chips to be received, the sizes of pans and trays must be varied accordingly and supplementary boxes or trays on wheels are essential for frequent removal.

Drip-can Method of Supplying Lubricant

Various methods of supply and collection are illustrated in connection with this treatise by drawings of various machines, but these are only a fraction of the immense number of modifications which exist in practice. The drip-can is the oldest form of continuous supply and is still employed extensively for operations where its limited feed is suitable and sufficient. It is often included on machines which

have a pump outfit as well, for use when the ample flow provided by a pump is unnecessary, the can being preferred when the class of work for which it is suited has to be done for a considerable time. The usual design is that of a cylindrical vessel, preferably with a cover, and an inside strainer of gauze (unless the liquid is strained previously). The can body is made of either sheet metal or cast iron. If the capacity of a cylindrical can is insufficient, a rectangular tank is sometimes used instead, as on some shafting lathes with multiple rests. Variations occur in the manner of holding the can, and the position and number of outlets. As a can, in most cases, is placed quite close to the point of application of the liquid, a short pipe is all that is necessary; this may be single or double-jointed, to bring the spout to the location desired. The can is either placed upon a flanged

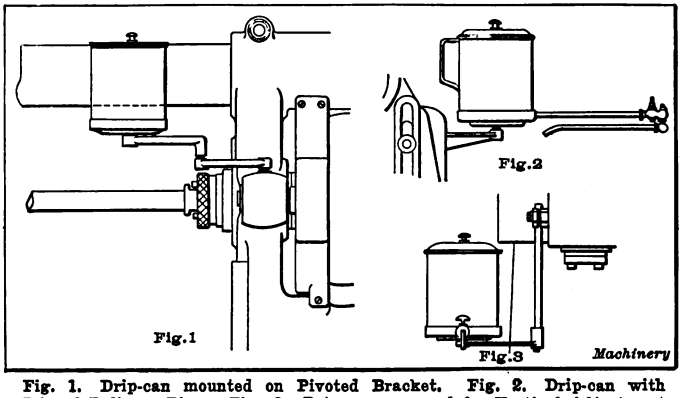


Fig. 1. Drip-can mounted on Pivoted Bracket. Fig. 2. Drip-can with Jointed Delivery Pipe. Fig. 3. Drip-can arranged for Vertical Adjustment

tray, supported upon a pillar fixed in any convenient position, or it is held either by a band, or stem and wing-nut on a slotted arm beneath, to permit of radial or vertical adjustment. The vertical adjustment is not of so much importance because the lubricant can be directed to fall on the work, but considerable adjustment in a horizontal direction is desirable, especially in machines where the cutters or tools occupy varied positions. Figs. 1, 2 and 3 illustrate common methods of adjustment. Fig. 1 shows pivoted arms, on the outer one of which the can is held; Fig. 2, a fixed bracket with jointed pipe, which gives much the same result; and Fig. 3, a suspension rod. The latter is employed on vertical milling machines, etc., to permit radial and vertical adjustments.

When the construction of a machine will not permit placing a can close to the tool, use is often made of flexible tubing of rubber or metal for connecting the can and spout.

Pumps for Cutting-tool Lubricating Systems

The drip-can ceases to meet the requirements when the quantity of lubricant that must be delivered exhausts the contents of the can in a

few moments. A pump which is automatic and under the control of the attendant is then the only method of providing a sufficient supply. Four types of pumps are in use: Centrifugal, plunger, wing, and geared, the latter being in the majority. The centrifugal pump is not used to any great extent but is sometimes preferable when there is grit in the lubricant. The plunger pump is employed only to a limited extent, although in the early days it was probably the only kind used for supplying drills and boring tools for deep-hole work in lathes. Where a large supply is desired or where the parts of the machine run at such a slow speed that there is no opportunity for drawing a rotary pump at a proper speed, the plunger type is still used, the most notable example being that of certain bolt-threading machines.

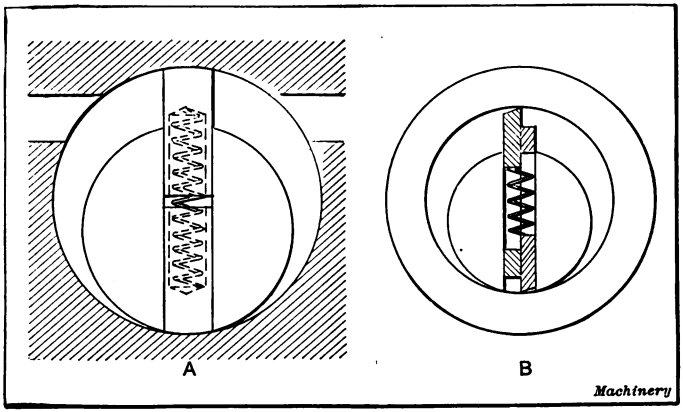


Fig. 4. Two Types of Wing Pumps for Cutting Lubricant

The construction of the wing type of pump comprises a casing with a chamber bored eccentrically (see Fig. 4) with relation to the spindle bearing. The enlarged head of the spindle is slotted to receive a pair of flat plates or wings, pressed apart by a brass spring or springs, so that as the spindle rotates, the ends of the plates maintain contact all around inside the chamber, thus drawing the liquid in and discharging it in one direction or the other according to the way in which the spindle rotates. These pumps will lift the lubricant a slight distance, but it is better to submerge them to avoid priming. A modification of the ordinary method of making the wings as illustrated at *A* is shown at *B*. The latter type is manufactured by Messrs. C. Wicksteed & Co., Ltd., of Kettering, (England) for use with their hacksawing machines. The wings, instead of meeting at the center, are thinner and pass right through the spindle head. Slots are cut in each section, as shown, so that a single spring presses the halves apart equally. The wings are tapered at the ends so that when a full discharge is not required, the pressure of the liquid will press the

wings back. This renders the use of a relief or overflow valve unnecessary.

The geared pump, a type employed to a far greater extent than any other, is of simpler construction, the essential parts being a pair of spur gears revolving inside a closely fitting case and drawing the liquid around in the tooth spaces. This type has no delicate parts to get out of order, and if properly built, enables high pressures—up to 1000 pounds per square inch—to be obtained. These high pressures are, of course, not necessary for feeding to external cutting tools, but for deep-hole drilling, in which great force is necessary to remove the chips, they are utilized. The low pressure pumps work to 100 pounds per square inch or less. For the average machine, it is merely necessary to raise the liquid and overcome the friction in the pipes and dis-

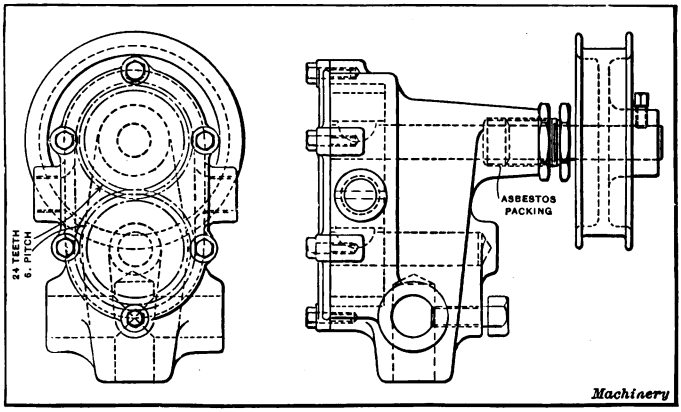


Fig. 5. Rotary Pump of Gear Type

tributor; any surplus pressure is only useful for washing away chips, the need for which varies with the class of operation. Some kinds of chips fall naturally out of the way whereas others tend to clog the work and the cutters. Some materials will stick to the cutters or work if lubricated to a moderate extent, and may require a larger stream and greater pressure to dislodge them. The removal of long curling chips, especially heavy ones, is not facilitated by the force of the stream, unless they are forced out of a hole.

The geared pump, an example of which is seen in Fig. 5, is rated to deliver a certain quantity at a definite number of revolutions per minute, and it may be run at higher or lower speeds if desired, with a varying output. The pump shown is made by Messrs. H. W. Ward & Co., Ltd., of Birmingham, (England). In place of the usual foot, it has holes to slip over a piece of shaft secured to the machine in any convenient location. This permits of setting the pump in three different positions, according to the belt location. The following table gives the capacities of two sizes of Brown & Sharpe geared pumps, with driving pulleys of 3½ inches and 5 inches diameter, respectively:

CAPACITIES OF PUMPS FOR LUBRICANTS

	Revs. per Min.	Capacity, Quarts per Min.	Suction	Discharge
No. 1	300	4	$\frac{3}{8}$ inch	$\frac{1}{4}$ inch or $\frac{3}{8}$ inch
	500	8		
No. 3	300	20	$\frac{1}{2}$ inch	$\frac{1}{2}$ inch or $\frac{1}{2}$ inch
	500	40		

The lift ranges up to 20 feet, but it is preferable to put the pump as near the level of the tank as is convenient, the exact location depending upon the type of machine and the facilities for attachment to the side of the framing or the edge of the tank or pan. The method of driving depends partly upon the position of the pump and partly upon the designer's ideas. The belt or cord drive is the most common. Spur gearing and chains are also used to a lesser extent, the advantage of these being that there is no bother with slipping belts nor trouble due to the splashing of oil. It is often more convenient to drive the pump by gears or chain from some constant-speed shaft

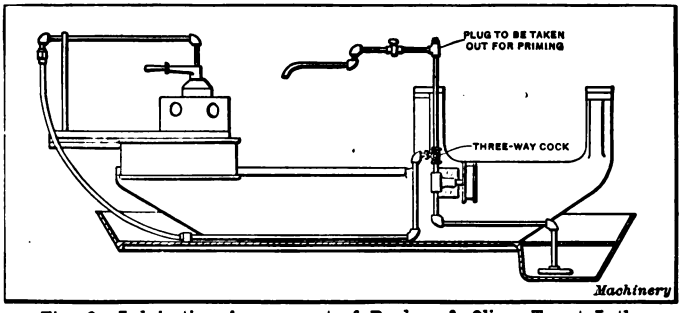


Fig. 6. Lubricating Arrangement of Bardons & Oliver Turret Lathe

on the machine than by a belt from the countershaft; when a motor drive is installed, the gear or chain method is especially applicable. The pump is thrown out when necessary, by sliding the gears out of mesh or by disengaging a clutch, if a chain is used. Generally, pumps run in one direction, provision being made to drive them from a shaft or countershaft which does not reverse, but when the machine reverses at intervals, as with certain automatic screw machines, the pump is slightly modified to enable it to run in either direction.

The fittings which are directly connected with the pump system include a strainer, which is submerged in the liquid and prevents access of grit or chips, and a relief valve, which is closed by spring pressure but opens when the flow is reduced or stopped at the delivery outlet, allowing the lubricant to run back to the tank through a by-pass. Sometimes a check valve is placed between the pump and the tank, but not invariably. Fig. 6 shows the piping for a Bardons & Oliver turret lathe, including a flexible supply pipe to the turret center for feeding hollow tools, and the diagram *A*, Fig. 7, shows the piping for a Brown & Sharpe milling machine. These two views represent, in principle, the arrangement of many machines. A pump for

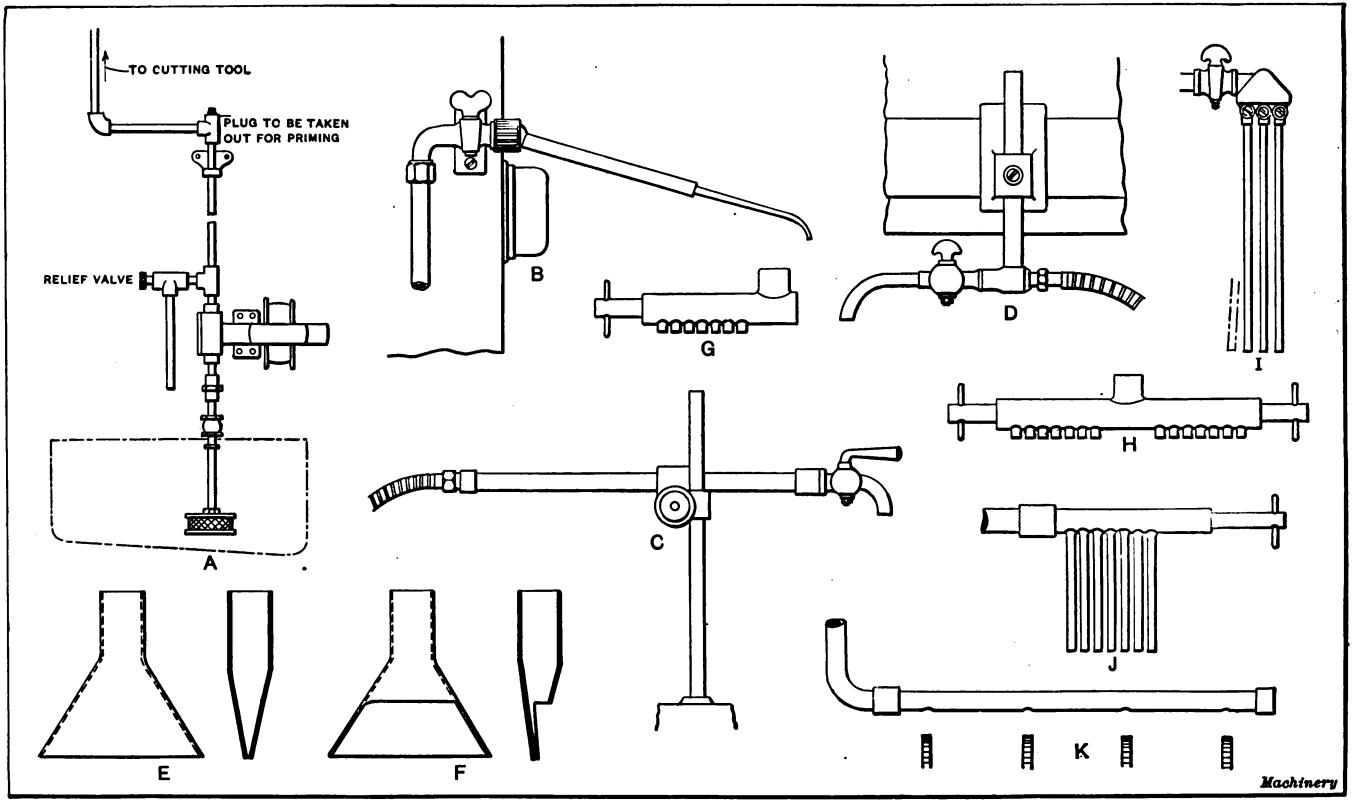


Fig. 7. Various Arrangements of Piping and Nozzles for distributing Lubricant to Cutting Tools

each unit is dispensed with in certain cases, as, for example, "batteries" of automatics or of sensitive drills, which are fed from a common supply instead of having a pump for each machine.

Methods of Distribution

The two points which we now have to consider are the means of distributing the lubricant to the tool or tools, and the means for catching the lubricant and returning it to the tank. The methods of distributing and returning the lubricant vary greatly on account of the varying conditions of cutting and different arrangements of tools, slides, machine framings, etc.

In regard to the method of distribution, the choice lies between rigid pipes, flexible pipes, and jointed pipes; between a single outlet, two or more outlets, a perforated distributor, a pipe with a number of taps or pipes leading from it, or an over head reservoir fitted with outlet pipes. Means may be provided in the case of multiple outlets to shut off any or all of these according to the amount of lubricant desired and its place of delivery. The flow may be allowed to fall from above, or it may be directed precisely to a certain spot by a pipe, or through a hollow tool or spindle, or a spout or chute may catch the lubricant and pour it onto a precise location.

Rigid pipes are chiefly applicable to machines which have no great changes of tools or adjustments of slides, so that a fixed position of the pipes is suitable, but these are the exception, and it is better to have an adjustable pipe, for convenience in moving it out of the way if necessary. The degree of movement depends on the range of possible locations of the cutting tools. Piping with three or four joints is frequently necessary, including horizontal and vertical swivel adjustments. The alternative is the flexible pipe, which, however, is likely to be in the way in many instances. A flexible pipe is more useful as a means of connecting rigid or jointed pipes to the supply or drawing-off arrangements.

A single outlet is all that is necessary for most of the single-point cutting tools, for narrow milling cutters, drills, and similar tools, but two or more outlets are required for pairs or gangs of cutters and multiple tools, unless the alternative of a single wide spout is utilized. The main support of a jointed pipe is placed according to circumstances, sometimes consisting of the supply pipe itself, sometimes of a separate rod to which it is attached, the rod being bolted or screwed in any convenient position. The main pipe or rod must be put where it is not likely to be in the way of large work, jigs or fixtures; in some cases, a portable fitting may be necessary to meet these requirements. An alternative to the gas-bracket type of jointed pipe is one having a ball-joint and telescopic second tube (see *B*, Fig. 7).

A preferable method of securing flexibility is to use a short piece of pipe equipped with a tap, and hold this in a clip against a part of the machine or on a rod, and connect to the pump with flexible tubing. This arrangement is useful when no great range of adjust-

ability is essential and also when considerable horizontal or vertical range is required. In the first case, it obviates the use of a jointed pipe, and in the second it enables adjustments of several feet to be obtained without encumbering the tool with three or four jointed pipes. Typical examples are shown at *C* and *D*, Fig. 7, *C* showing a rigid pipe held by a split clamp to a rod screwed into a machine boss and connected to a flexible tube, and *D* a stem extending from the connection and clamped in a bracket horizontally adjustable along a slide. As the flexible pipe can be carried down at the rear or side of the machine, it need not interfere with the operation of the machine; moreover, if cutting is done without lubricant, the clamps may be released and the piping laid out of the way altogether. Arbor supports or overhanging arms on the machine are often used for attaching pipe clamps.

A cutter of considerable width, or a hob, must have an ample supply of lubricant along its entire length, if lubrication is to be effective and even, and cooling uniform. A good device for hobs and cutters for heavy duty is the fan nozzle. This is set vertically, or at an angle, just above the cutter, and delivers a broad copious stream. The closed type *E*, Fig. 7, is employed in the case of slab millers having the cross-slide face set at an angle, the nozzle being pointed inward or toward the back of the machine. The partly open kind *F* is suitable for horizontal delivery or delivery at a slight angle. These nozzles are attached to the delivery pipe, but in a few instances the nozzle is used separately, being clamped to a part of the machine or to the tool itself and fed by a flexible pipe brought over it, thus affording a wide stream without modifying the outlet for ordinary operations.

Adjustment for width of flow is provided for in some nozzles, the opening being blocked to any desired extent by sliding a plug along to suit the width of the cutter. When there is no adjustment to the supply pipe to accommodate the varying lateral positions of cutters on their arbors, the nozzles may be pointed to right or left, as desired, by fitting it with a swivel joint. Perforated distributing pipes which give a flow of lubricant to suit the length of work or cutter are shown at *G*, *H* and *J*, Fig. 7. They have sliding plugs to shut off some of the holes, thus reducing the supply. Pipe *G* is an ordinary form, *H* is double-ended (a type useful for gang mills on an arbor which is steadied by a central support) and *J* has extension tubes hanging down to reach in between tools which interfere during part of their stroke, with a directly vertical flow. This type of distributor is also used where the air from a belt or other rapidly moving part would disturb the vertical stream of lubricant and blow it out of its proper path. At *I* the tubes are pivoted to swivel to one side and direct the liquid to a particular place. A shut-off may or may not be provided for each tube.

The standard distributing pipes occasionally fail to meet special conditions, and it becomes necessary to cut a piece of tubing and

drill it specially, as at *K*, where four slitting saws are set rather far apart and a pipe is drilled with holes to suit. If much of this class of work is likely to be done, it may be preferable to drill a larger number of holes in the pipe and plug up those not wanted. Long distributing pipes are sometimes provided with holes drilled fairly close together and having spring bands which are partly rotated to block those holes which are not required. Another special arrangement for some classes of work where a guard is fitted over the cutters is to use the hollow top of the guard for conducting the lubricant directly upon the cutters. Box-tools are also sometimes made with hollow frames, with an outlet close to the cutters, giving a broad

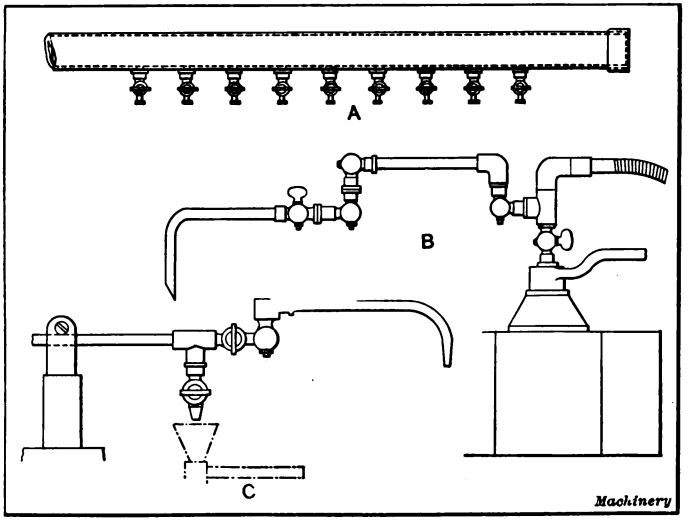


Fig. 8. A. Distributor with Row of Taps. B. Combined Supply Pipe for Interior of Turret and External Tools. C. Supply Pipe feeding into Funnel on Box-tool

stream at the best possible location. This is a mode of distribution that must be designed to suit the tools, and is not of general application.

An alternative to the practice of stopping off or plugging up unused holes in a distributing pipe is to provide regular taps for turning off the lubricant. This method is common to milling machines of the planer type, on which a pipe of ample capacity is secured to the cross-rail and has a number of taps screwed in at close intervals, as shown at *A*, Fig. 8. If the pipe runs along at the back of a machine or below a cross-rail, as in many multiple-spindle drilling machines, pipes connected to each tap will be essential in order to bring the oil to the drills, a swivel-joint permitting each pipe to be placed in the position desired.

The case of two or more pipes having outlets separated more widely than in the distributors referred to is often met with, such as when two tools or cutters are working on different parts of a piece

or on two pieces of work. Either rigid or swiveling pipes are used, according to requirements, or provision for variation between the outlets is made by a length of flexible pipe. Certain multi-spindle drilling machines and multi-spindle automatic screw machines carry a pipe partly around the spindles or around the turret, and various bent pipes or distributors lead off from this common supply pipe to feed each drill or turret tool. At *B*, Fig. 8, is an example of a double supply, one pipe leading to the center of the turret for lubricating hollow tools, and the other continuing for feeding external tools held in the turret. A somewhat similar arrangement is shown at *C;* the tap nearest the turret feeds into a funnel which is connected to a slot distributor attached to one of the box-tools having a long cutter for

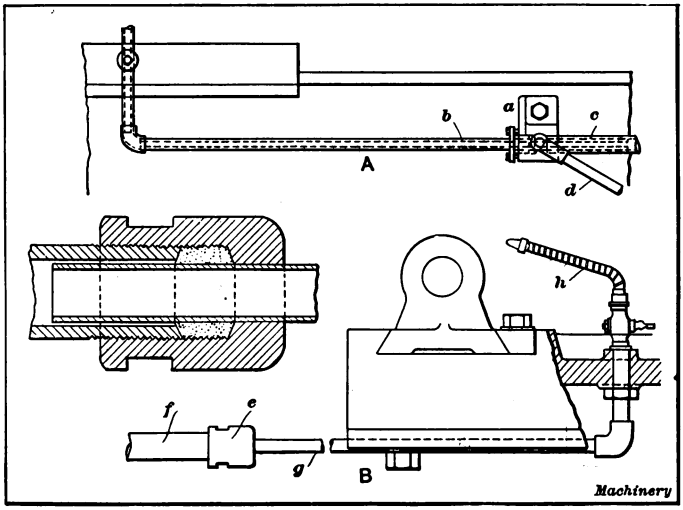


Fig. 9. A. Sliding Pipe and Stuffing-box of Turret Lathe. B. Telescopic Pipe Connection for Carriage of Gear-cutting Machine

forming steel taper pins; this arrangement insures a proper flow all along the broad-faced cutter.

Portions of machines which move intermittently or continuously along a bed, and must be fed with lubricant in any position they occupy, require the use either of jointed pipes, flexible connections, or telescopic tubes. Both of the latter are largely used. The flexible tubes are likely to get in the way and become a nuisance, while the telescopic pipes can be arranged in snug fashion and occupy a minimum of space; moreover, they are not as liable to become damaged as flexible tubes. It is chiefly in those types of machines where the tool has a horizontal feeding movement that the provision of adjustable piping is required. Gear-cutting machines and turret lathes are the most frequent examples, the cutter-slide of the one, and the turret-slide of the other requiring a supply of lubricant at all working positions. Certain other machines of less importance in point of

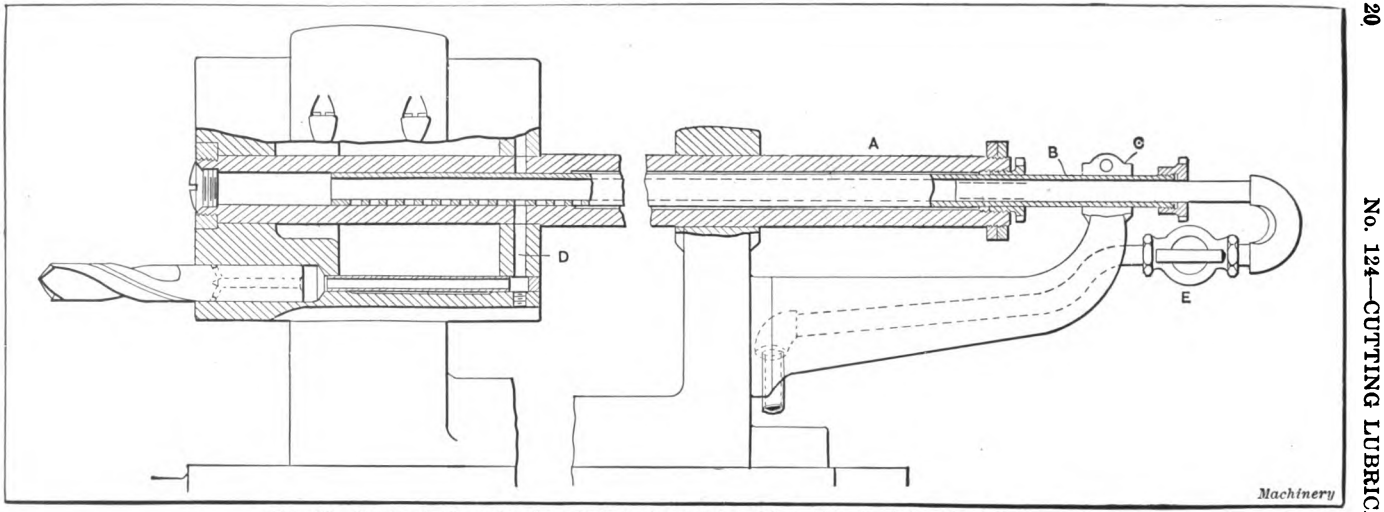


Fig. 10. Sectional View showing Method of supplying Oil to Turret of Cleveland Automatic

numbers, such as horizontal drilling machines and slot-drills with traveling cutter-heads, also require adjustable piping. The telescopic device *A*, Fig. 9, which also shows the back of a turret lathe with a portion of the turret saddle, has a fixed bracket *a*, fitted with a stuffing-box through which the sliding pipe *b* is free to move. The latter passes into the closed end of pipe *c*, which is fed by the pipe *d*, from the pump.

Connection to the sliding cutter-carriage of a gear-cutting machine is made either by the somewhat clumsy means of a flexible pipe, or by a sliding pipe which is arranged, preferably, below the base, as at *B*. (From the practice of Messrs. J. Parkinson & Son, Shipley, England.) The packed gland *e* (shown enlarged in section above) is screwed on the end of the stationary pipe *f*, and admits the sliding pipe *g*, which is united to a short vertical pipe fixed to the cutter-

carriage. From this vertical pipe the short length of flexible steel tube *h* directs the stream onto the cutter.

Another system of distribution for movable parts is that requiring a supply to tools in a turret, one or perhaps two or more of which may require the lubricant to be fed through their hollow bodies during their period of operation only. This is effected by causing the rotation of the turret to turn on and cut off the oil as the tools come into their working position. The arrangement for the Cleveland automatic screw machines is shown in Fig. 10, and will serve to illustrate the

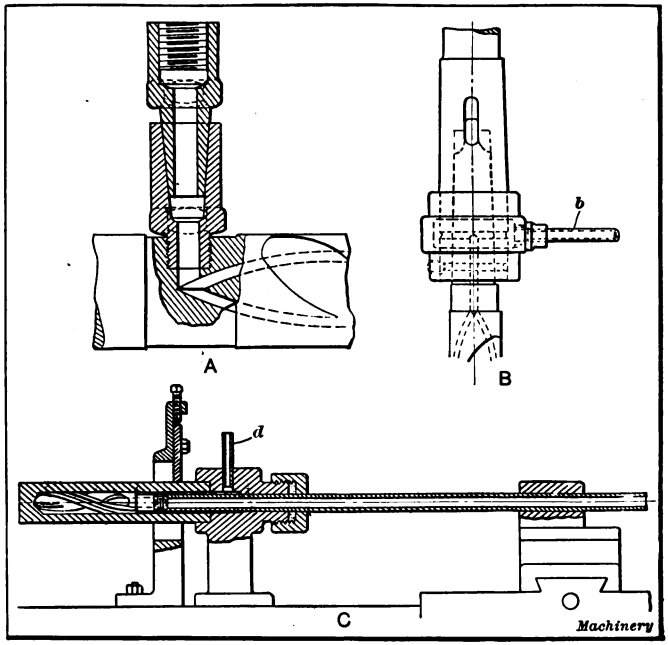


Fig. 11. A, Connection to Oil Passages of Stationary Drill; B, Connection to Oil Passages of Rotating Drill; C, Method of Lubricating Hollow Drill for Deep Hole Work

principle. The feed takes place when the drill shown is at the lowest or working position. The turret shaft *A* in its to-and-fro movements, controls the feed in the following manner: An oil tube *B* extends inside the shaft and can be clamped in the bracket *C*, whenever desired. This tube has a series of holes in its lower side, continuing for a distance equal to the turret stroke. These holes communicate with a single hole *D* connecting with a tube inserted in the turret hole which carries the tool. The position of tube *B* determines when the oil will begin to flow; it can be adjusted to start at the beginning of the stroke, or later. Valve *E* is to regulate or shut off the oil. Can action is employed in some machines to turn the oil on and off.

The cutting tools which require a supply of lubricant through their hollow bodies include drills, reamers, counterbores, boring tools, and, less frequently, taps. Threading dies are also fed by a pipe which floods their interior, or the threading machine may have a hollow spindle through which the oil is pumped. Long drills or their separate holders, not held in a turret, usually have the supply pipe screwed in at the end and the oil goes to the cutting end by way of open grooves or grooves covered with strips soldered over; sometimes holes are drilled in the solid metal to the cutting point, or pipes are laid in recesses along the body of the tool. If the oil is not taken through the end of the drill it may be supplied as shown at *A*, Fig. 11. This method is suitable for any class of drilling machine or turret lathe in which the drill does not rotate. Connection to a flexible tube enables the drill to feed along to any desired extent.

A modification in the form of a loose collar, as at *B*, is necessary to permit a drill to revolve. The collar is held from revolving by the supply pipe *b*. The oil is sometimes fed by gravity but it should preferably be pumped through; it passes to the passages which communicate with the holes or tubes of the drill. A cup-shaped collar is sometimes used, the oil being poured in from the top. In all these tools, the chips find their way out of the hole by the flutes or spaces of the tool, but in the hollow drills used for deep holes, they have a special outlet. The oil is fed by way of the body grooves, and the cuttings escape through the flutes, the hollow shank and an extension tube (see sectional view *C*, Fig. 11.) A stuffing-box surrounds the tube and the oil is pumped through pipe *d*, and goes along the outside of the tube and past the shallow flutes on the lands of the drill. The oil then forces the chips back through the main flutes and out through the shank and the tube. The hole must be first drilled to a depth equal to the body length of the drill, before the latter can be used with oil, this preliminary operation being done with a short starting drill.

Methods of Recovering Used Lubricant

The methods of catching, draining and returning the oil are simple on some of the smaller machines, but more complicated on the larger ones, particularly on types which use lubricant very freely. The provision for lubricant often affects the design of the frame and many of the smaller details. The simplest catching device is a can hung underneath a table, this being emptied into the drip-can overhead at intervals. This is quite satisfactory when the quantity of lubricant used is very small, but like the drip-can, it fails to meet requirements when a flow of any magnitude is required, and a proper tank must be employed. The three principal means of receiving waste lubricant are, by a suspended tank, a tank on the floor or bolted to the machine base, or by using the hollow base of the machine to form a tank. The pans which surround the bases of so many machines come under the second category. The suspended tank is objectionable only on account of its limited capacity; the second class can be made of any

desired dimensions; the tank in the base is a means of profitably utilizing the interior space, thus making it unnecessary to provide a separate receptacle.

The simplest method of dealing with the question of waste lubricant will be to follow the lubricant in its course, from the point where it leaves the work. It is also necessary to take into consideration the provisions for dealing with chips, since these affect the matter vitally.

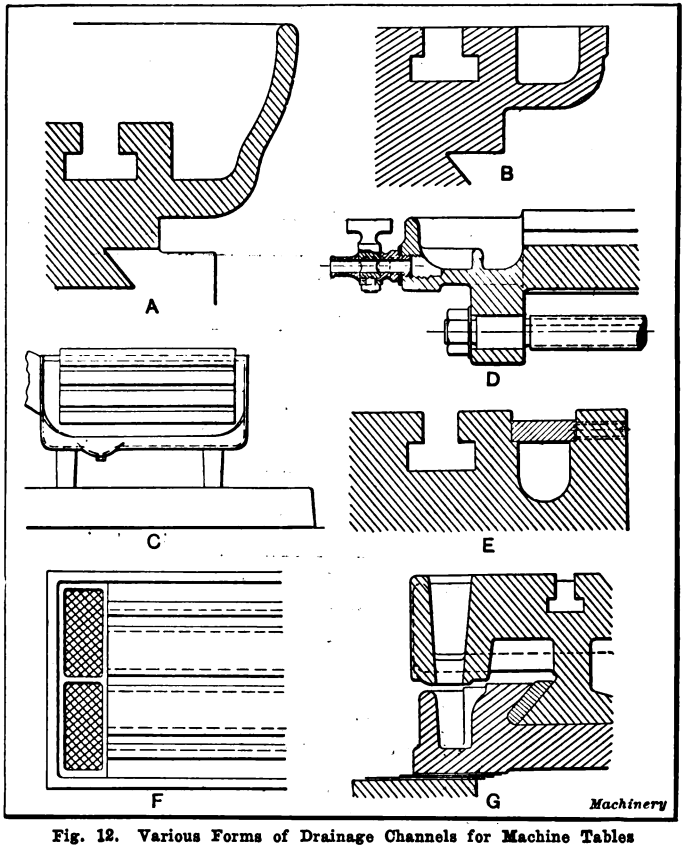


Fig. 12. Various Forms of Drainage Channels for Machine Tables

All work which is machined is held either on or over a table, or it may project beyond the bed or slide. In the first case, the table receives the waste oil, in the second, the oil either falls directly into a trough or is caught and diverted in various ways. Tables, when not intended for use with oil, simply have slots or tee-slots, and there is no rim or other provision to prevent a lubricant from falling onto the floor. The addition of a turned-up rim prevents the lubricant from escaping, excepting by the way of a spout or a hole, whence it drains into a can hung under the spout or tap, or falls through a rigid or

flexible pipe, or by way of rims on subsidiary slides, to a tank below. The height of the rim is limited, in the majority of cases, by the level of the table, the rim being just below the table, but there are some exceptions. When it is known that the size of work or of jigs or fixtures will never exceed the bounds of the tee-slotted surface, then it is possible to raise the rim as shown at *A* in Fig. 12. This high rim is desirable when splashing is likely to occur. It is the practice now, with a great many milling machine manufacturers, to machine the oil rim flush with the table top as at *B*, in order that it may be utilized

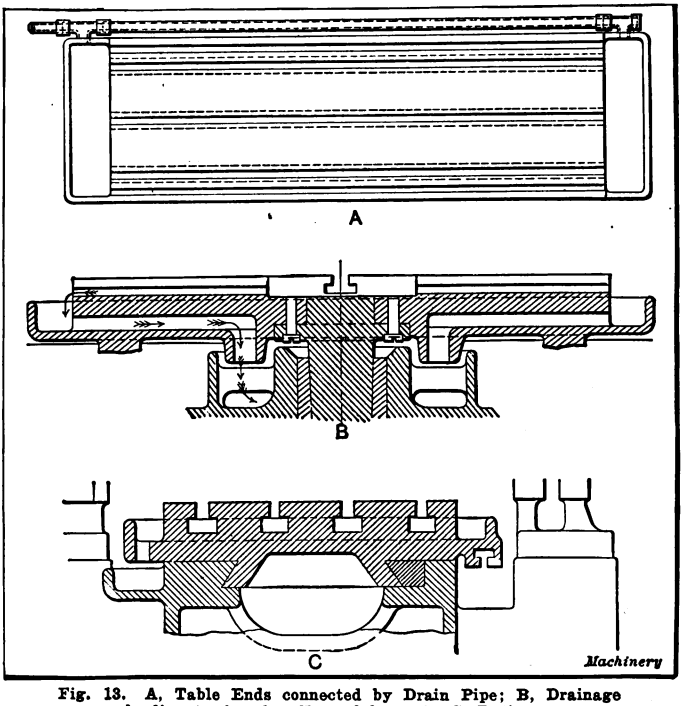


Fig. 13. A, Table Ends connected by Drain Pipe; B, Drainage leading to Annular Channel beneath; C, Drainage Channel for Reciprocating Table

as a support and form part of the table surface. Large fixtures which hang over the working surface can thus be held, and dividing heads can also be set further apart than on a table with the rim set below. If a table having a vertical face, in addition to the horizontal top face, has to be drained, the oil rim is cast as shown at *C*, which is the table of a radial drill. The channel follows around the table and has a small well at the bottom, into which the waste collects and is drawn off by a tap or pipe.

Draining the Lubricant to the Supply Tank

The end of the table is the place most commonly selected for drawing off the lubricant, because it is more convenient to apply or attach

a can, or to connect a pipe. The sectional view *D*, Fig. 12, shows the end of a milling machine table, with a draw-off tap and an enclosure adjacent to the hole to prevent chips from blocking up the tap. Another device to prevent choking, which impedes the proper flow of the lubricant, is to fit guard strips to the channels, as at *E*, so that they cannot be quickly clogged with chips and thus cause table flooding. The filling up of the end pockets with chips is avoided on some tables by the use of removable strainer plates, as at *F*, which shows a plan view. These plates are set at about one-half the channel depth so that there is a clear space beneath for the liquid. In the milling machines made by Messrs. D. & J Tullis, Ltd., of Cyldebank (Scotland), the end pockets are connected by a pipe (*A*, Fig. 13), instead of having a deep channel on each side of the tee-slotted surface, com-

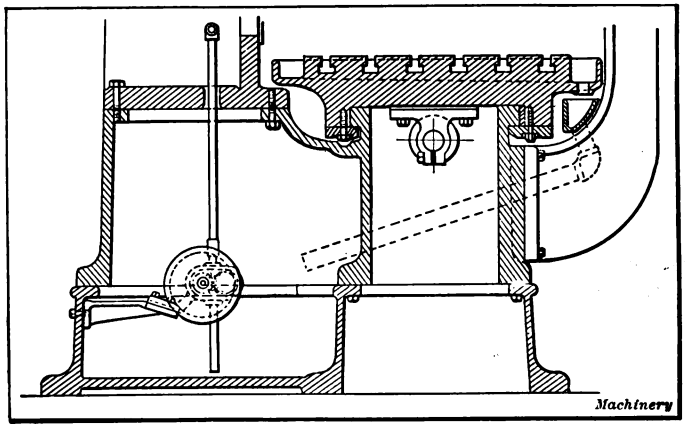


Fig. 14. Drain from Table into Tank in Base of Machine

paratively shallow grooves being milled in the top to conduct the waste to the pockets.

When a square or a circular table has to make complete revolutions, the waste is preferably drained through the center into a tank or a hollow bed, the alternative to this being to surround the table with a fixed pan into which the oil drips and is drained therefrom through a channel into a receptacle below. In the central drainage system, the precise course of the oil ducts depends on the manner in which the table is mounted. If there is no central spindle, but merely a hollow boss, the oil can flow down through this, but if a solid spindle occupies the center, the drainage takes place through passages situated some distance out, as at *B*, Fig. 13, which shows a gear-hobbing machine table. The oil falls into a rimmed enclosure and thence through apertures which lead down to a tank between the slideways.

The location of a spout or lip, when no pipe is connected, must depend upon the facilities for catching and the opportunities for maintaining the lip always over some portion of the pan or other receptacle. Frequently, it is impracticable to insure the latter condition, and then

piping, or special chutes leading to the main tank have to be used. If a table or slide has a limited range of travel in relation to some part below it, the part below can, in certain instances, be utilized as an intermediate drain. The section *G*, Fig. 12, of a milling machine table and slide, is an illustration. When, as in large plano-miller tables, there is no other moving part, arrangements have to be made to receive the oil at any longitudinal position. This is done by casting or bolting a trough to the side of the bed, just below the overhanging drain hole or spout of the table, and locating the drain hole in such a position that it will never run past the lower trough. The oil drains from the latter into a tank or hollow bed. A typical arrangement is shown at *C*, Fig. 13, and also in Fig. 14 (from a Walcott

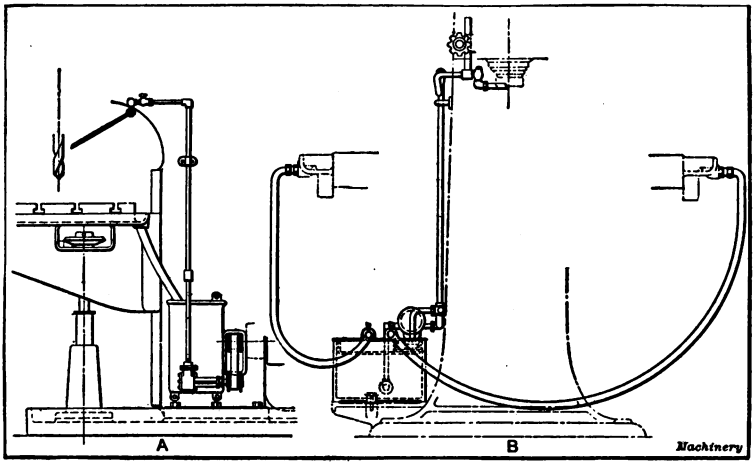


Fig. 15. A, Lubricating System for Drilling Machine; B, Supply and Return System of Vertical Milling Machine

rack cutter), which includes the drain pipe from the trough into the hollow base and the pump and suction pipe.

Flexible tubing is employed very largely for drainage purposes. The only objection to it (beyond that of possible choking if of too small a bore) is that it gets in the way of the operator, on some machines, especially when the movements are of considerable range and therefore necessitate long pieces of tubing. In a case like the one illustrated at *A*, in Fig. 15, there is no inconvenience, because the tube is short and close to the frame, but at *B*, which shows an Alfred Herbert, Ltd., vertical milling machine, the tubes are of necessity long and somewhat cumbersome. Some of this firm's horizontal machines have a telescopic arrangement of piping extending from the cross-slide on the knee to the tank alongside the frame (as shown at *A*, Fig. 16), which accommodates itself to the vertical and horizontal positions of the slide, and takes the place of a flexible connection. The lower view *B* shows how a flexible drain tube is applied under

similar circumstances, this example being from French practice. A slide with vertical movements can be drained by pipes, as represented at *C*. These pipes are telescoping and the lower one conducts the oil to a pan from which an outlet leads to the tank. Section *D* illustrates the drainage into the hollow frame of a drilling machine. There is a slot *a* of sufficient length to permit the pipe to travel up to the limit of the table adjustment.

Guards and Splash-plates

Two other details which are required for many types of machines are the guards and splash-plates which prevent the oil from flying

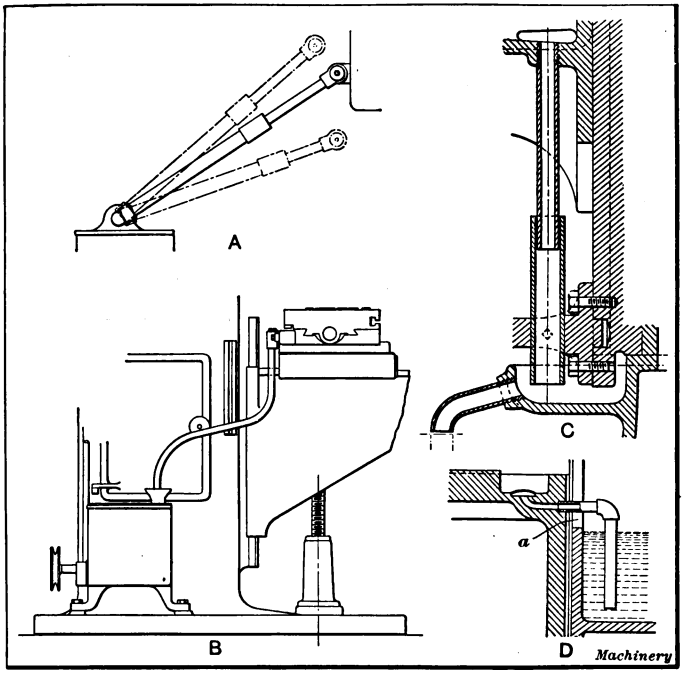


Fig. 16. Drainage Connections to permit Vertical Adjustment of Work Table

beyond the limits of the machine or drainage pan. These devices are necessary chiefiy for work rotating rapidly and comprise curved plates or castings around chucks and parts of spindles as well as around rotating work, and flat or curved plates held opposite the spindles or work, at some distance, so as to deflect the waste down into the pan. Sometimes drills are also encircled by sheet guards to catch the oil thrown off by the curling chips. All these types of guards are usually removable to facilitate the work of the operator, and are either clipped to convenient places or hinged to swing back. A clip for holding a flat guard is shown at *A*, Fig. 17. This is also a convenient device for holding curved pieces to fit around the angles of a pan or base,

instead of riveting the clips permanently to the splash-plate. At *B* is represented a hinged guard for protecting the whole of an automatic screw machine head, two of these being used. They can be swung down below the pan for inspecting the head. Hinged guards

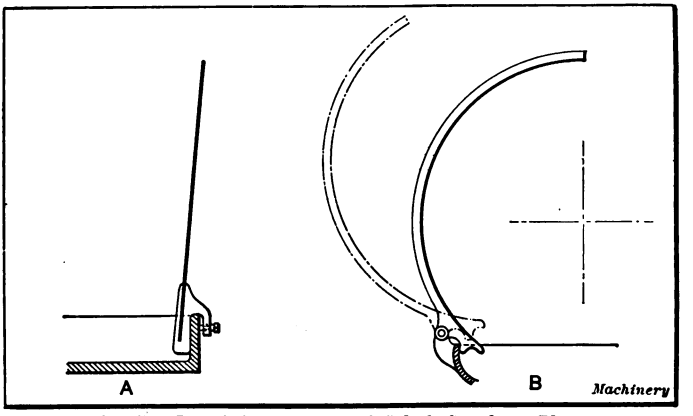


Fig. 17. Detachable and Pivoted Splash Guards or Plates

are also fitted around the tables of boring and turning mills, when lubricant must be used and the speed of rotation is rather high.

Drainage Pans for Cutting Lubricant

The nature and capacity of the drainage channels and drip-pans on any machine, depend both on the quantity of lubricant which is likely to be employed and the course which it takes after leaving the tools

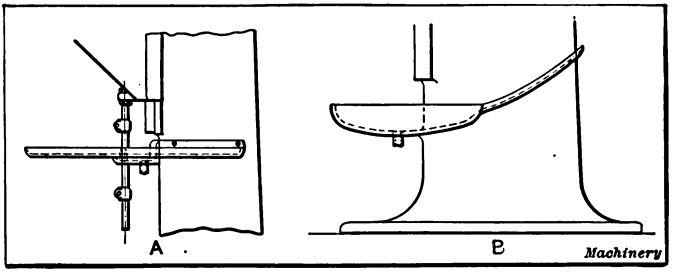


Fig. 18. A, Lubricant Tray attached to Column; B, Lubricant Tray cast integral with Column

and work. Lubricant which does not escape from the bounds of a table and is caught immediately by a pipe, or other means, does not, of course, require channels or pans for collecting it; but if there is extensive splashing, catching-lips, trays, or regular pans become essential, until, in the final development, the whole machine stands in a large pan having deep sides. With a minimum of splashing or dripping, which causes a small amount of oil or suds to trickle down the frame of a machine, a simple tray screwed on (as at *A*, Fig. 18) is

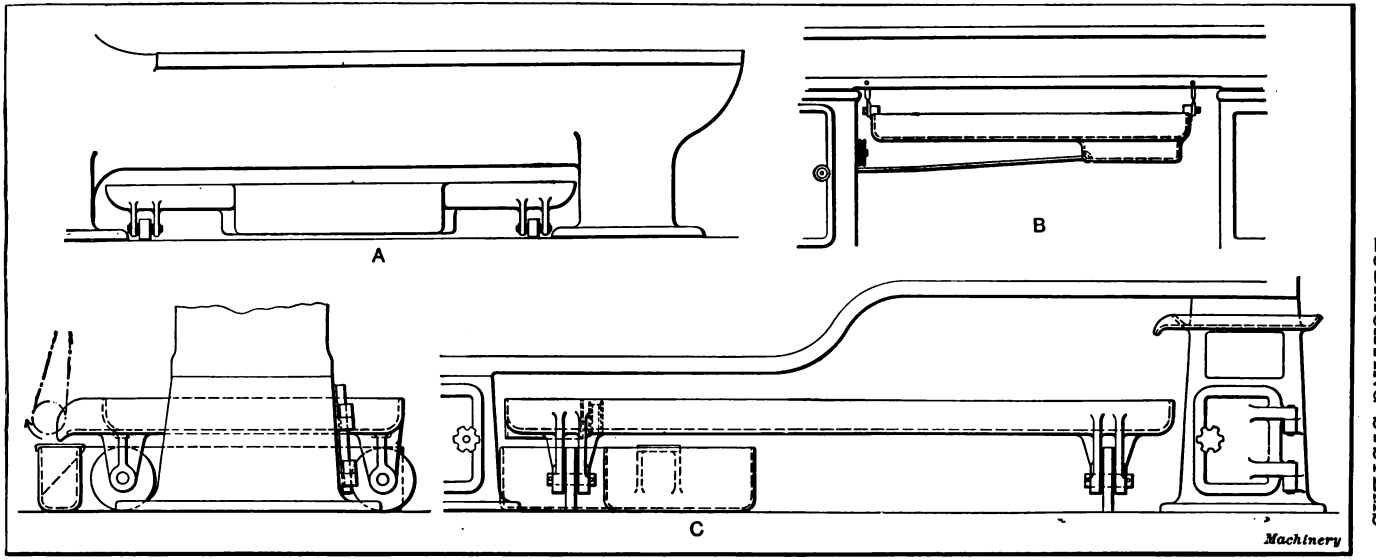


Fig. 19. Different Designs of Drainage Pans

sufficient, or the column may be completely encircled with a channel, as at *B*, the depth being increased at the front to hold a moderate quantity of oil.

A portable pan is often attached to a portion of a machine beneath the area of operation to receive the chips and lubricant, the latter draining through a pipe and away. Portable trays are also used on some boring and milling machines; these are placed under particular locations where lubricant drips down, and a flexible pipe connects the trap to the tank. A few examples of different arrangements of pans are given in succeeding illustrations. The detail *A*, Fig. 19, shows a portable pan with a well com-

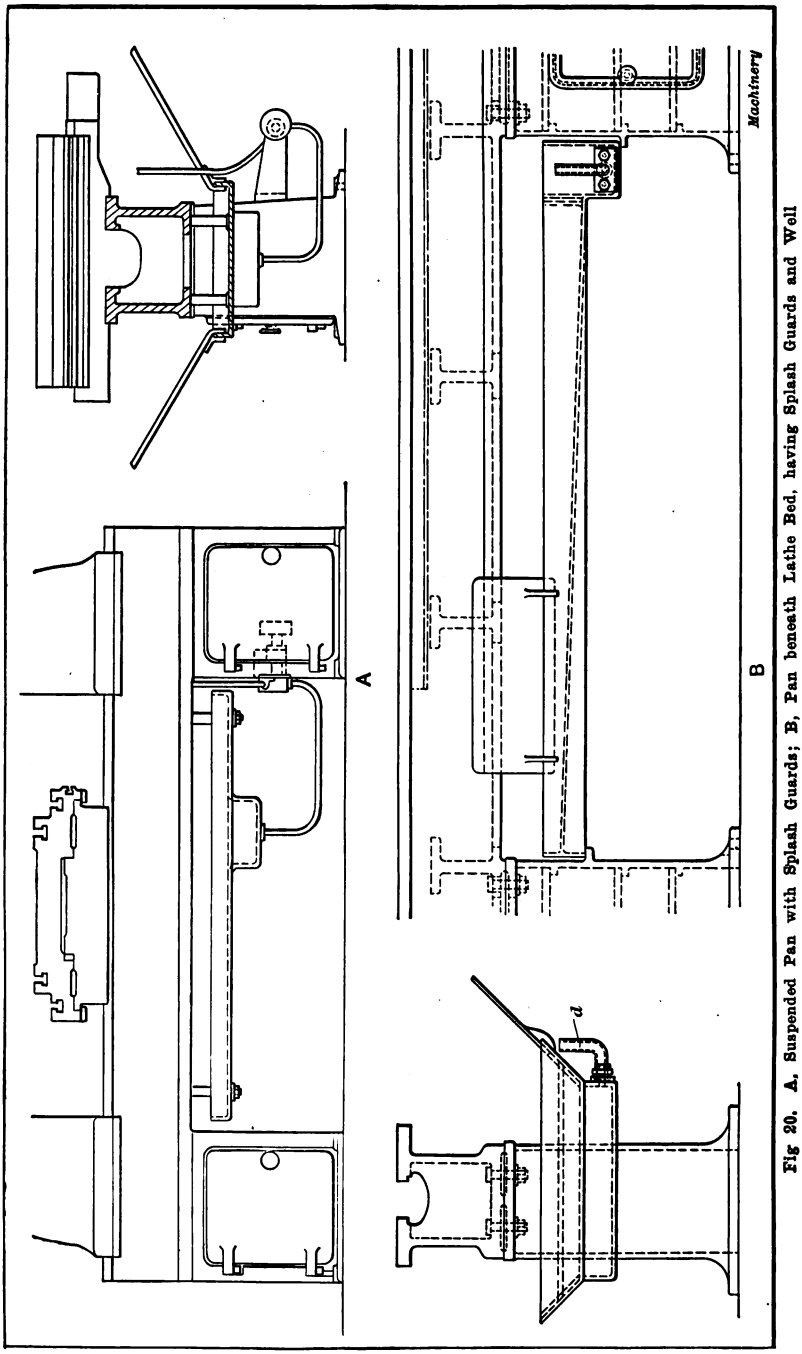


Fig 20. A, Suspended Pan with Splash Guards; B, Pan beneath Lathe Bed, having Splash Guards and Well

bined; illustration *C* shows another portable pan which has a separate tank that is fixed and carries the pump. The portable pan has a lip, as shown in the end view, to drain into the tank beneath. The right-hand cabinet leg has a channel surrounding it which drains into the portable pan. For dealing with large quantities of chips, the pan on wheels is preferable to the fixed pan from which the chips have to be removed and transferred to some other receptacle for disposal. At *B*, Fig. 19, is shown a fixed pan that is suspended beneath the machine. This practice is common in Germany because it enables pans to be added only when required, leaving the machine otherwise suitable for operation without cutting

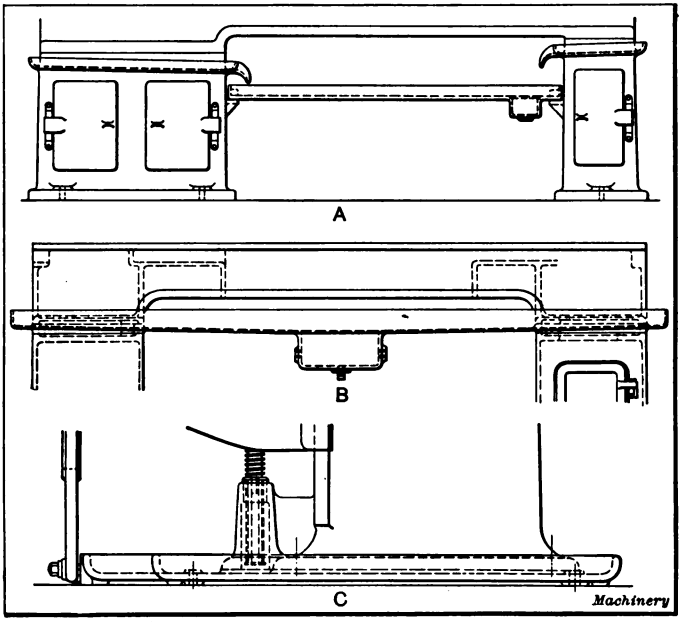


Fig. 21. Other Drainage Pan Developments

lubricant. Another suspended pan (on a Greenwood & Batley special milling machine) is shown at *A*, in Fig. 20. This pan is hung on four bolts and has plates to catch the drip from the overhanging table. A pan with splash-plate attached is shown at *B*. This pan is supported on lugs cast on the cabinet legs and has a well and drainage pipe *d*. The method of fitting a pipe of this kind is shown in Fig. 22. It has a packing ring *a* which is clamped by the shoulder of the bent pipe; the latter is held in by the gland plate *b*. In the position indicated, the pipe drains off the contents of the pan, but when turned vertically, as shown by the dotted lines, it retains the lubricant in the pan, forming a simple tap or drainage cock.

A further development is shown at *A*, Fig. 21, the drainage system including channels around each leg, so that no oil can escape, except-

ing into the pan; in a more complete system, the whole bed stands in a pan interposed between it and the legs, as at *B*. This is common practice with some classes of small milling and other machines which rest upon a floor stand, and with the smaller automatic screw machines. The larger ones either have a turned-up foot all around the base, or the whole machine stands in a large tray which is partly

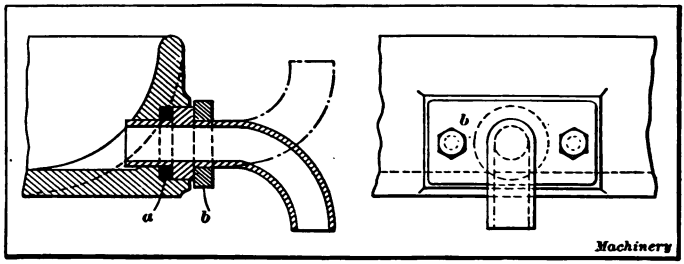


Fig. 22. Combined Drainage Pipe and Tap

filled with lubricant, the depth of the tray ranging from a few inches to a foot or more. Milling machines standing in a separate tray, as at *C*, do not require such a large oil capacity as "automatics," especially of the multi-spindle type. The latter often have a hollow cabinet leg which contains an extra oil supply. Supplementary sloping chutes overhang the edges of the trays of some automatics to receive drippings from projecting turret slides and spindle ends.

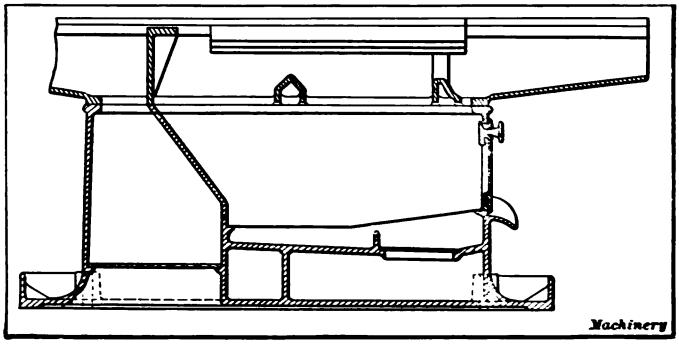


Fig. 23. Hollow Base of Turret Lathe used for Receiving Chips and Lubricant

The practice of receiving all the chips and lubricant entirely within the bed is noticeable in the Pittler (German) turret lathes (Fig. 23). The interior has a plate and grid to catch and drain the chips and there is a door at the end for their removal. The vessel to contain the chips is placed under the drainage lip by the door. The remaining portion of the machine frame, to the left, forms a tool cupboard. This utilization of the interior of the machine base to hold the oil, in order to avoid the provision of an outside tank, is a practice becoming increasingly popular. The bases of drilling machines (see

Fig. 24), milling machines, gear-cutters, etc., often form excellent tanks for the reception of cutting lubricant. The chief objection with some designs is the difficulty of cleaning the tank. If the chips cannot enter the hollow body, this objection is negligible, but if they are

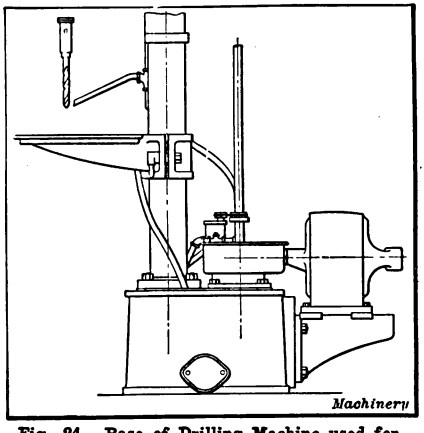


Fig. 24. Base of Drilling Machine used for Lubricant Tank

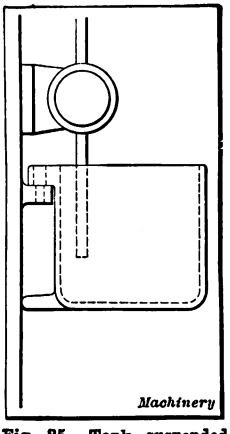


Fig. 25. Tank suspended on Lugs to permit Easy Removal

free to fall in with the oil (as in Fig. 26), the chips become a nuisance. For this reason, special facilities are afforded for cleaning the tanks from which pumps draw their supply, in cases where the chips are fine and difficult to keep back. A tank, instead of being bolted down, may be hooked over a pin standing up from a lug (Fig. 25), without

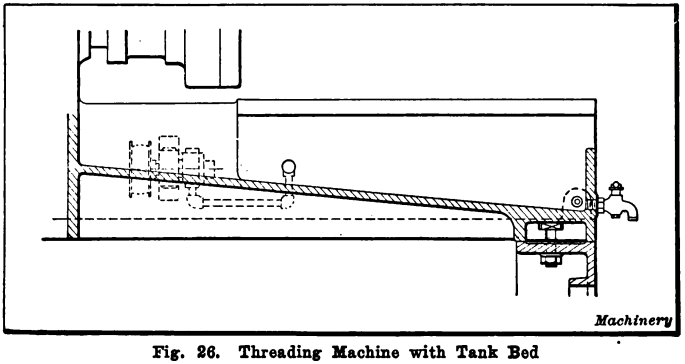


Fig. 26. Threading Machine with Tank Bed

interfering with the pipes, or it may be tilted on lugs (Fig. 27). The tanks for Lincoln millers are often suspended in this way.

Separation of Chips and Lubricant

The separation of chips presents little difficulty, when they are large and cannot possibly pass through a small opening which admits the

lubricant; but when they are fine, like the small chips from threading machines, etc., and particularly those from hacksaws or cold saws, the greatest care has to be taken to prevent their entering the pump. This is done in two ways: By using strainers, and by fitting divisions or weirs so that two or three have to be passed before the liquid

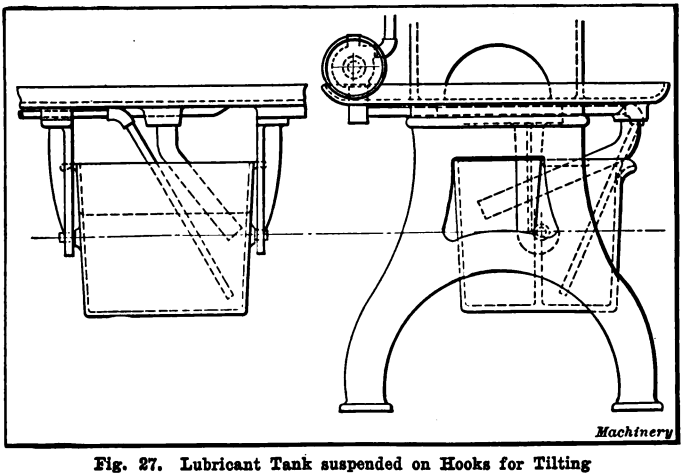


Fig. 27. Lubricant Tank suspended on Hooks for Tilting

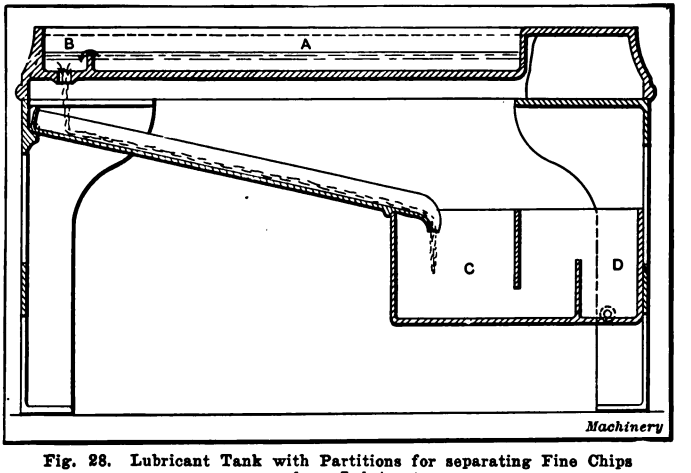


Fig. 28. Lubricant Tank with Partitions for separating Fine Chips from Lubricant

reaches the pump chamber. An example is shown in Fig. 28, which illustrates the frame of a hacksaw machine built by Messrs. C. Wicksteed & Co., Ltd., of Kettering (England). Soap-water is used as a lubricant; this is first received in the recess *A* in the bed, and is drained at the front end *B*, which is farthest away from the falling swarf or chips as they are carried back by the blade on its return

stroke. A sloping trough then conveys the lubricant to the tank *C*, which has two divisions, as shown. Light swarf which floats on top cannot pass over the first division, and the clear liquid goes underneath to the pump chamber *D*.

If chips are produced in moderate quantities, it is well to have a separate perforated tray resting on the main pan, and empty this as required. One form is shown in Fig. 30. This tray should be deeper

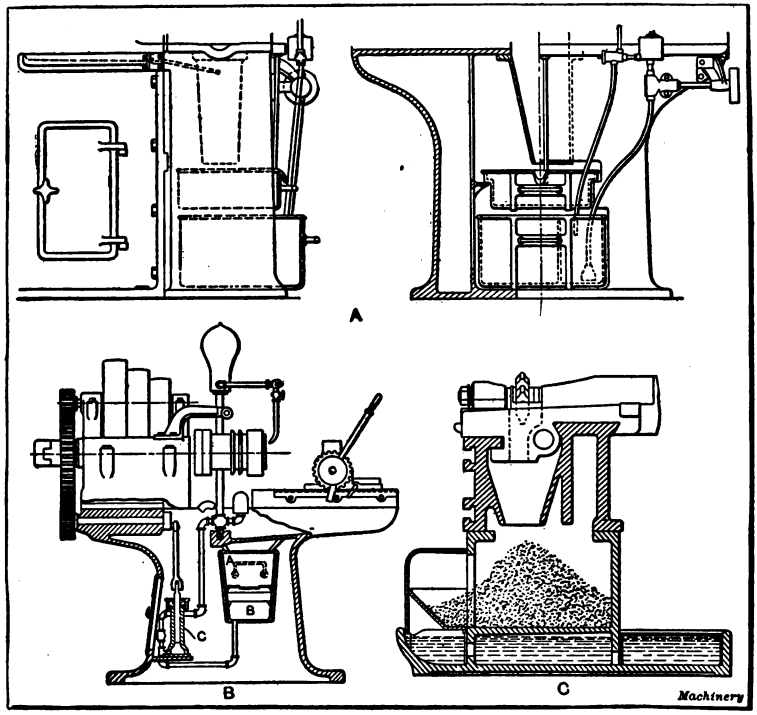


Fig. 29. A, Drainage Tank placed above Main Supply Tank; B, Common Lubricating Arrangement for Threading Machinery; C, Gear-cutting Machine with Provision for storing Oil in Base

when larger quantities of material are handled, and is placed over the main tank, as shown at *A*, Fig. 29. It is drawn out when full, for getting rid of the chips. For threading machines, the usual arrangement is represented at *B*. This view shows the chip box *A*, with strainer and the settling tank *B*, with a division which prevents any sediment that might pass through the strainer from entering pump *C*. The latter is of the plunger type, and there is an air-vessel on the delivery pipe to insure a more constant flow of lubricant. In some designs, the interior, where the pump is located, forms an oil reservoir of larger capacity than the tank *B*.

Oil is contained only in the foot or base of some machines, corresponding in this respect to automatic screw machines, and the interior of the frame or the bed is used only to receive the chips. The sectional view *C* illustrates a large Brown & Sharpe automatic gear-

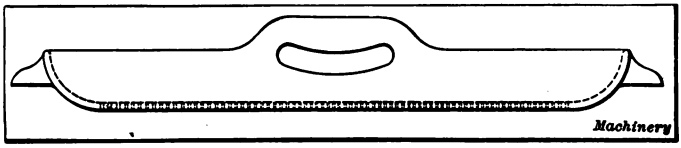
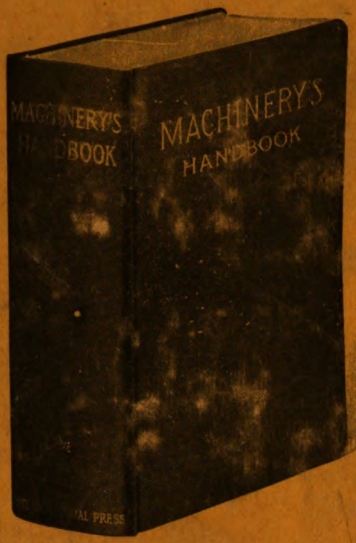


Fig. 30. Perforated Tray for separating Chips from Lubricant

cutting machine having this arrangement. The base stores the oil (from 25 to 30 gallons) and the chips fall from the cutter-slide to the position indicated, accumulating at the front eventually, and being removed through the opening for treatment in the oil separator.



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